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Prior generic arthroscopic volume correlates with hip arthroscopic proficiency: a simulator study

Abstract

Background: Changing trends in surgical education and patient expectation are leading to proficiency models of progression and the use of simulators. Hip arthroscopy continues to increase in frequency and has a significant learning curve mainly addressed during fellowship training. The aim of this study was to assess the impact of previous generic arthroscopic experience on performance at a simulated hip arthroscopy task in order to both estimate the minimum numbers that correlate to expert proficiency levels and to help guide selection for hip arthroscopy fellowships.

Methods: 52 participants were recruited to a cross-sectional study. Four 'Consultant' (Attending with a hip arthroscopy practice); 28 'Trainee' (Residents and Fellows); 20 'Novice' (Interns and medical students) performed a standardized bench top simulated hip arthroscopy task. A validated global rating scale (GRS) score and motion analysis (MA) was used to assess surgical performance. Prior arthroscopic experience was recorded from surgical eLogbooks. Receiver operating characteristic (ROC) curve analyses were conducted to identify optimum cut points for task proficiency at both 'expert' and 'competent' GRS levels.

Results: There were significant differences between the arthroscopic ability of all experience groups based on GRS assessment ($p < 0.002 - 0.0001$) and for all MA metrics ($p < 0.0079 - 0.0001$). There was a significant positive correlation between logbook numbers and GRS scores ($p < 0.0001$). ROC curve analysis demonstrated that a minimum of 610 prior arthroscopic procedures were necessary to achieve an 'expert' GRS score while 78 were necessary for a 'competent' score.

Conclusions: Performing a basic hip arthroscopy task competently requires significant previous generic arthroscopic experience. The numbers identified in this study provide targets for residents and indicate the importance of obtaining high operative numbers during residency. **Program directors** appointing to hip arthroscopy fellowship training posts may find these results useful **as a guide** during the selection process.

Introduction

From the first arthroscopic description of a labral tear in 1986¹ hip arthroscopy has grown in popularity and emerged as a recognized technique for diverse hip joint pathologies²⁻⁶. A significant learning curve is said to exist mainly due to a deeply confined, highly congruent surgical field and the use of an unfamiliar 70 degree arthroscope⁷⁻¹². Despite its popularity and difficulty, there remains limited literature on the use of hip arthroscopic surgical simulation¹³.

There is a reported general increase in arthroscopic caseload amongst orthopedic residents^{14,15}. **Hip arthroscopy is the fastest growing field within arthroscopic surgery and orthopedic trainees are more frequently exposed to it**^{5,6,15}.

Investigators exploring the trend and variability of arthroscopic experience during orthopedic residency have described how health education authorities and regulators, such as the Accreditation Council for Graduate Medical Education (ACGME), have established case-load minimums for select orthopedic surgeries^{14,15}. However, educationalists argue that that using case volume as a benchmark of competency is contentious given the scarcity of evidence to support its use^{16,17}. As such, current thinking may be moving away from a competency based model to a proficiency-based progression model for which arthroscopy education, and in particular the use of simulators as an adjunct, is considered to be suitable^{15,18-20}. In addition, there is evidence that public policy may be a driver for simulation. Reported patient expectation strongly suggests (94%) that all surgical trainees have compulsory simulation experience before real-time exposure²¹.

While many surgeons feel there is no substitute to real-life surgical experience, there is a growing interest in simulation-based arthroscopy training²²⁻²⁴. The learning curve in hip arthroscopy, much like in any other orthopedic subspecialty, is at present addressed mainly during fellowship training or advanced practitioner courses²⁵⁻²⁷. Importantly, concerns have been highlighted on the range of experience, and by way of extrapolation: 'ability' of a trainee on commencing or applying to such fellowship opportunities¹⁴. This disparity may result in trainees not achieving their full potential during the course of the fellowship program. Such concerns, in the context of political pressures to ensure the return of highly skilled surgeons against substantial

healthcare investment have resulted in attempts to objectively assess trainees ²⁸⁻³³. Therein lies a dichotomy, where increasing reliance now exists on fellowship training to bridge the shortfall in experience that is largely caused by changes in post-graduate surgical training and the well documented global reduction in working and training hours ³⁴⁻⁴⁰. Changing training from a time-based to a competency-based system does not overcome such working time restrictions ^{41,42} and therefore explains the subsequent shift in training philosophy to that of proficiency-based models ⁴³⁻⁴⁵. As with many other surgical sub-specialties, simulation-based training is being adopted in orthopedics in an attempt to broach the training gap. Researchers have now begun assessing simulators beyond construct validity in order to push for transfer validity of simulation training ⁴⁵⁻⁵³. This has been observed specifically in arthroscopic procedures of the knee and shoulder, where the modality of operating lends itself well to simulation ^{22,46,47,54-60}.

There is currently no recognized structured training scheme for hip arthroscopy but there is a growing demand for a limited number of good fellowship programs. Trainers who have been entrusted with selecting potential fellows into such programs have a difficult task of identifying the most suitable candidates. Although previous experience in arthroscopic surgery is considered an important selection criteria for sports medicine fellowship programs, the exact impact of previous arthroscopic experience on an applicant's suitability for a hip arthroscopy fellowship has not been defined.

This study uses a validated hip arthroscopy simulation model to assess the impact of previous **non-hip** generic arthroscopic experience on performance at a simulated bench top task and identifies guideline minimum numbers that correlate to the proficiency level of an expert hip arthroscopist.

Materials and Methods

Subjects

Fifty-two participants with varying degrees of previous arthroscopic experience were assessed while performing a simple simulated hip arthroscopic task. Participants were divided into experience groups depending on the number of previous

arthroscopies they had performed. Only the expert, referred to in this study as the 'consultant' group had performed actual previous hip arthroscopies. **Indeed, all experts regularly performed hip arthroscopy as part for their routine practice.** The prior arthroscopic experience of all subjects was ascertained by the interrogation of validated operative logbooks. Only previous arthroscopic operations actually performed by the participant (supervised or unsupervised) were included (knee, shoulder, foot and ankle).

For ease of data representation, there were 3 experience groups. The 'novice' group consisted of medical students who had no prior arthroscopy experience and interns who had minimal operative exposure. The 'trainee' group included orthopedic residents of varying seniority and fellows undertaking a knee or shoulder fellowship. The 'consultant' group describes expert end-users, effectively hip surgeons with a recognized hip arthroscopy practice.

The structure of our residency program results in trainees gaining their arthroscopic experience in a non-linear fashion. Accordingly, when considered in the context of a cross-sectional study, splitting the cohort to reflect seniority during residency was inappropriate. In addition, with the expectation of inter-program heterogeneity, grouping of the trainee cohort allows for an overall assessment of how prior generic training experience relates to simulator performance.

Institutional review board approval was granted for this non-patient study.

Arthroscopic Simulation

The simulated hip arthroscopy task was conducted in a dedicated surgical skills laboratory in the academic department of a university teaching hospital. Participants used standard 70° hip arthroscope and access set (Smith & Nephew Endoscopy, Huntingdon, United Kingdom). A previously validated bench-top hip arthroscopy simulator (Sawbones Europe, Malmö, Sweden) with established reinforced optimum anterolateral (1 cm anterior to the proximal tip of the greater trochanter) and anterior portals (located at the intersection of a sagittal line drawn from 2 cm lateral to the anterior superior iliac spine and a transverse line level with the anterolateral portal)

with a fixed 1 cm distraction in the supine position was used ¹³. Participants performed a validated 7 point diagnostic task. Points 1 to 4; corresponded to labral positions, points 5 and 6 corresponded to acetabular chondral lesion, and point 7 to the ligamentum teres ¹³.

Prior to performing the task, all candidates watched an instructional presentation that included an embedded video demonstration of the task. Immediately after the presentation, all candidates were asked to perform a single diagnostic hip arthroscopy of the central compartment triangulating and touching the numbers sequentially with an arthroscopic probe.

Assessment of Arthroscopic Skill

Global Rating Scale

Synchronized video recordings were made from both the arthroscopic digital output and external webcam footage of the candidates' hands. The primary outcome measure employed was a previously validated version of the Basic Arthroscopic Knee Skill Scoring System (BAKSSS) global rating scale (GRS) ^{30,59}. The GRS was used by a blinded observer to score the synchronized recorded videos of each participant's performance ³⁰. In keeping with prior bench-top simulator studies ^{30,61}, GRS was modified in order to assess the technical domains of the task which consisted of control of the instruments, the depth perception, bimanual dexterity, flow of the operation, efficiency and final quality of execution. These 6 domains were assessed on a Likert Scale ranging from 1 to 5, thus the maximum possible GRS score was 30, and the minimum score was 6. Having been trained in the use of the GRS for arthroscopic skills assessment, two of the authors (GE and AA) performed blinded assessments **on a sample** of the video recordings using the GRS.

Motion Analysis

The secondary outcome measure was the use of a validated motion analysis (MA) system (PATRIOT; Polhemus, Colchester, Vermont) to objectively measure surgical performance. The outcome measures were time taken (seconds), total path-length of the hands (centimeters), and number of hand movements. With increasing operative experience and seniority, surgeons have been shown to require less time, shorter path-lengths and fewer hand movements ^{46,47,62-64}.

Statistical Analysis

The primary outcome measure was the GRS score and the secondary outcome measure was the MA metrics. The Kolmogorov-Smirnov test confirmed requirement of non-parametric tests with data presented as medians and interquartile ranges (IQRs). The Kruskal-Wallis test was used to compare differences in performance across groups when based on GRS and MA metrics. Where differences were found, the relationships between individual surgical experience groups were analyzed with Mann Whitney tests. The Spearman's rank correlation coefficient was used to test the relationship between GRS and MA parameters for arthroscopy experience. The Cronbach α coefficient was used to determine inter-observer reliability of the GRS. Receiver Operating Characteristic (ROC) curve analyses were then used to explore and identify any cut-points in relation to previous arthroscopic procedures performed. Cut-off points approximate to the point where sensitivity and specificity are best matched, which in turn corresponds to a 45° tan- gent line intersection ⁶⁵. Random sampling with replacement, also known as bootstrapping ⁶⁶, was applied to estimate the 95% confidence intervals (CIs) around the cut-off points. All analyses were performed using SPSS version 18.0 software (SPSS, Chicago, Illinois) or Stata version 13 (StataCorp, College Station, Texas). A p-value of < 0.05 was considered significant.

Source of Funding

Project funding support was received from the National Institute for Health Research (NIHR) Biomedical Research Unit.

Results

Cohort Demographics

A total of 52 candidates were studied: 4 consultant or expert-level (consultant); 10 fellowship-level and 18 residents (28 trainees); 10 interns and 10 medical students (20 novices). No participants were excluded or failed to complete the study.

A broad range of prior arthroscopic experience was seen throughout the cohorts of expert, trainee and novice. (Table 1).

Global Rating Scale

Two observers were analyzed for inter-observer error across 5 (9.6% of the total) randomly selected videos. The Chronbach α was 0.89 demonstrating excellent inter-rater reliability. A single observer assessed the remaining 47.

There were significant differences in GRS scores across all experience groups (overall and novice versus trainee: $p = 0.0001$; trainee versus consultant: $p = 0.002$) (Figure 1).

Motion Analysis

Significant differences in all MA parameters were seen across the study (time, path length and movement number: $p = 0.0001$). Between-group testing revealed significant differences in all three MA parameters (novice versus trainee; $p = 0.0001$; trainee versus consultant, time, path length and movement number: $p = 0.001$, $p = 0.005$, and $p = 0.008$ respectively). In comparison to the GRS, the spread in MA performance across the trainee cohort demonstrates less spread. (Figure 1: box whisker plot B versus plots A, C and D).

Correlation of Logbook Numbers and Primary and Secondary Outcome Measures

Spearman test demonstrated a significant relationship ($p < 0.0001$) between GRS and arthroscopic experience.

Receiver Operating Characteristic (ROC) Curve Analyses

Figure 2 shows the scatter plots to assess an individual's experience (numbers of arthroscopies performed) against **total** GRS performance in the simulated task. A steep learning curve was identified with large increases in performance on the GRS during the first 80 arthroscopies. The Consultant group showed the most consistent level of performance, with 2 achieving a **cumulative** GRS of 30 (full marks) and the other 2 a GRS of 26. The performance of the remaining participants improved with experience and approached the level of performance of the Consultants after approximately 80 to 100 arthroscopies.

Cut-off analyses were performed for varying degrees of GRS performance to identify the minimum numbers of prior arthroscopies required that would estimate a specific GRS performance on the hip simulator. The data revealed that expert levels of performance (5/5 in each domain of the GRS) required a minimum of 610 previous arthroscopies, whereas GRS of 4/5 and 3/5 required 78 and 47 respectively (**Table 2**).

Discussion

This study has demonstrated how previous generic arthroscopic experience correlated to performance at simulated basic hip arthroscopy. While most trainees did not achieve a 5/5 GRS throughout all 6 assessed categories, experts did. This allowed the use of ROC analysis to demonstrate that previous experience of 78 arthroscopic procedures are needed for the defined competent performance (GRS 4/5 in all domains), while 610 previous arthroscopies are needed before being able to perform this simulated hip task at the defined expert level (5/5 GRS in all domains). Even the lower number of 78 is higher than the expectations of the United Kingdom Joint Committee on Surgical Training (JCST) and the ACGME. While there is no specific requirement for hip arthroscopy, currently, the JCST requires 40 arthroscopic procedures to be performed for knee arthroscopy in order for the certificate of completion of training (CCT) to be awarded. In comparison, the ACGME requirement is 30. These numbers have recently been challenged by simulation data published suggesting that 150-200 arthroscopies are required before reaching the performance levels demonstrated by specialists for simple knee diagnostic tasks ⁶¹.

When considering hip arthroscopy, tactility, together with the joint congruity and field of view difficulties, may explain the learning curve or even the learning barrier ⁶⁷. This would seem further evidenced by the cut-offs demonstrated in this study. Expert users have also reported that a surgeon needs to have performed at least 30 hip arthroscopies before seeing a reduction in the operative time and complication rates ^{12,68}. While ultimately, trainees will have to experience the high-stakes environment of the real operating room (OR), research does suggest that one third of adverse events in the OR are avoidable and surgical technical errors dramatically affect

patient outcome ⁶⁹⁻⁷³. Such observations present a challenge to those responsible for fellowship training programs in determining how best to address what seems to be the steep learning curve for hip arthroscopy. A recent editorial considers this dilemma and refers to the ‘fulcrum effect’ as a consequence of reduced tactile feedback during hip arthroscopy ⁷⁴. Additionally, it adds that the task of training is compounded by the fact that there is inherent variation in the arthroscopic ability of trainees ⁵⁷.

In accordance with educational theory around psychomotor skill development through “sustained deliberate practice”, simulation models may play an important role in both the development and maintenance of expertise ⁷⁵⁻⁷⁹. Global changes in surgical training have used such educational principles to push for technical skills training and assessment on simulators. The increasing popularity of hip arthroscopy combined with the technical challenges that the procedure presents suggests it could lend itself well to simulation-based training. Nevertheless, to date, only one publication exists describing a hip arthroscopy simulation model ¹³. Although this was an inter-trainee comparison with no expert benchmark, the conclusion that all trainees would benefit from simulator training is in keeping with this study.

With regards to limitations, this was a simulated task performed on bench-top models and so it cannot be translated directly to the operating room. The basic nature of this simulator was previously described by Pollard et al ¹³. The setup is not designed to test many of the key hip arthroscopic skills such as joint distraction, portal positioning, radiography coordination, and involvement of the peripheral compartment. Variations in size, anatomy and bleeding are also not confounders in simulators of this variety. The skills tested are nevertheless key, and more importantly, the performance of experts was significantly different to trainees throughout thus demonstrating construct validity. In parallel to validity, and with specific relevance to the aim of the study, is the benchmarking of expert performance. Irrespective of the simulator’s limitations, the study determines a quantitative objective for trainees to aim for when considering aptitude for further fellowship training.

We fully recognize that GRS is not a complete descriptor of surgical performance; equally, volume alone is not purely determinate of surgical skill. Notwithstanding this, GRS was taken as a surrogate, being feasible option which can be employed by others. We feel that innate ability does play a role in

the performance of simple simulated tasks and is evidenced in this study by those surgeons who have performed well with relatively low quantitative experience.

Simple tasks will arguably lend themselves to a narrower data spread in MA (Figure 1: box whisker plots A, C and D). We believe that the GRS, being qualitative, demonstrates itself to be a more sensitive tool in discriminating the intricacies of movement. An example being, how roughly the tissues were probed, or the likelihood of articular cartilage damage caused by the spatially effective transition of probe movement. When this occurs without adequate regard to the intervening anatomical geography to be navigated, a lower GRS score is awarded. Such intricacies may be a reflection of experience rather than innate ability, and explain how the heterogeneity in trainee operative experience is more accurately intimated in the GRS data. These observations also partially address a perceived limitation of considering MA in simulated tasks, whereby the direct path is recorded as the most skillful. This situation may not be reflected in practice, particularly in more complex therapeutic tasks, where a potential correlation with decision-making exists. Furthermore, the simulated task was basic and not designed to test decision-making. However, despite the model's simplicity, experts scored significantly better than all trainees in both MA and GRS. The data exhibits a plateau after 600 joint-specific cases, appropriately reflecting the expertise of the consultant group. These findings support the notion that factors such as decision making are important and require further exploration.

In conclusion, this study demonstrates that even a basic hip arthroscopy task requires significant previous generic arthroscopic experience if the task is to be performed at a high level. This is in keeping with the described learning curve associated with not only arthroscopic procedures in general but with hip arthroscopy in particular. Although hip arthroscopy is considered a fellowship-learned skill we recommend that orthopedic trainees considering a career involving hip arthroscopy will get the most from the training experience if they have performed over 80 independent arthroscopic procedures in other joints prior to the fellowship. While such numbers do not mean operating room competence, they provide a useful guide

and starting point for those considering subspecialist training in this field and to those selecting trainees for fellowship programs.

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Table 1: Numbers of arthroscopies performed by group and per anatomy.

Table 2: Results of the ROC curve analysis for varying degrees of Global Rating Scale (GRS) performance across all tested domains that provide the optimum cut point with the corresponding area under the curve (AUC).

Figure 1: Box Whisker Plots of outcome variables against experience groups. (A) Time taken; (B) Global Rating Scale; (C) Path Length; and (D) Number of Hand Movements.

Figure 2: Scatter Plot correlating prior arthroscopic experience against **total** GRS score.